STRUCTURE AND FRACTURE FEATURES OF Ti-Si- AND Ti-B-BASED IN SITU COMPOSITES.

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Ti-Si- and Ti-B-based in situ composites as a class of discontinuously reinforced materials may provide simultaneous improvement in both specific strength and specific stiffness.

Systematic study of their structure and mechanical behavior in a wide temperature range shows that in the binary Ti-Si-system in dependence on silicon content the composite forms both polycrystalline structure at silicon content up to ~3-wt.% and dendritic-eutectic one at higher silicon content. At embrittling influence of silicon on titanium in general amount of silicon 2-3-wt.% is critical for as-cast state resulting in zero plasticity at intergranular fracture mode. Hot deformation suppresses this negative effect of 2-3-wt.% of silicon increasing room temperature ductility from zero to ~16 % and keeping it on level not less 9 % at higher silicon content. The reason of this phenomenon is purification of solid solution from silicon that results in change of fracture micromechanism from mixed cleavage + void coalescence in as-cast state for fully void coalescence in deformed state. Strength of deformed alloys increases with silicon from ~800 to 1000-1050 MPa reaching its saturation at around 4.0-wt.% Si.

Alloying the binary system with Al and Zr enhances its mechanical properties. With the sample of Ti-3Al-5Zr-Si *in-situ* it is shown that this material has complicated heterogeneous structure. It consists of typical for near α-titanium alloys two-phase α′-lamellas with β-phase along their boundaries, particles of secondary silicides of solid solution decomposition and intergranular (interdendritic) eutectic - alloyed titanium - $(Ti,Zr)_5(Si,Al)_3$ silicide. Increasing silicon content as well as high temperature plastic deformation are promoting to arising and increasing amount of the $(Ti,Zr)_2(Si,Al)$ silicides as well as of $(Ti,Zr)_x(Si,Al)_y$ composition.

Mechanical behavior of as-cast alloys under uniaxial tension in temperature range between room temperature and 700 °C is determined by behavior of both decomposed brittle prior β-grains and intergranular eutectic consisting of comparatively ductile matrix and silicide skeleton resulting in ductile intergranular fracture in alloy with 2 wt. % Si, brittle (by cleavage) fracture with some portion of ductile pore coalescence in alloys with 4 and 6 wt. % Si and low, near zero, general room temperature plasticity. High temperature plastic deformation at around 1100 °C gives significant enhancement of their room temperature plasticity and strength carrying them 4% (elongation) and 1 150 MPa respectively in alloy with 2 wt. % Si. Elongation of alloys with 4 and 6 wt. % Si reaches 2.7 and 1.8 % respectively at the same level of strength. Fracture mechanisms of forged composites are intragranular ones with pore coalescence and small portion of cleavage microcracking.

Reinforcing titanium with borides and jointly with borides and silicides especially like in Ti-3Al-5.7Zr-1.2Si-1.3B alloy shows clearly that Young modulus at level of 160 GPa at around 1500 MPa strength and 2-6 % room temperature plasticity may be ensured. Volume of reinforcing phase is unexpectedly high in 2-3 times in comparison with predicted by the equilibrium phase diagram. It is important that all the alloys studied being in deformed state fail with ductile mode evidencing that mechanical properties of alloys may be enhanced via optimization of structure.

Keywords: Titanium in-situ composites, discontinuous reinforcement, silicide reinforcement, boride reinforcement, ductile reinforcement, microstructure, α'-phase, β-phase, $(Ti,Zr)_5(Si,Al)_3$-silicide, $(Ti,Zr)_2(Si,Al)$-silicide, mechanical properties, fracture mechanisms.